HIGH-YIELDING WELLS IN METAMORPHIC ROCKS: INFLUENCING FACTORS

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INTRODUCTION

In December 1988, a hydrogeologic investigation was conducted at a 225-acre area in the Piedmont province near Atlanta, Georgia (Figure 1). The purpose of the investigation was to evaluate a method for selecting high-yield well sites in an area underlain by metamorphic rocks. The method consists of using site-specific geologic mapping and other field observations to delineate areas for drilling wells.

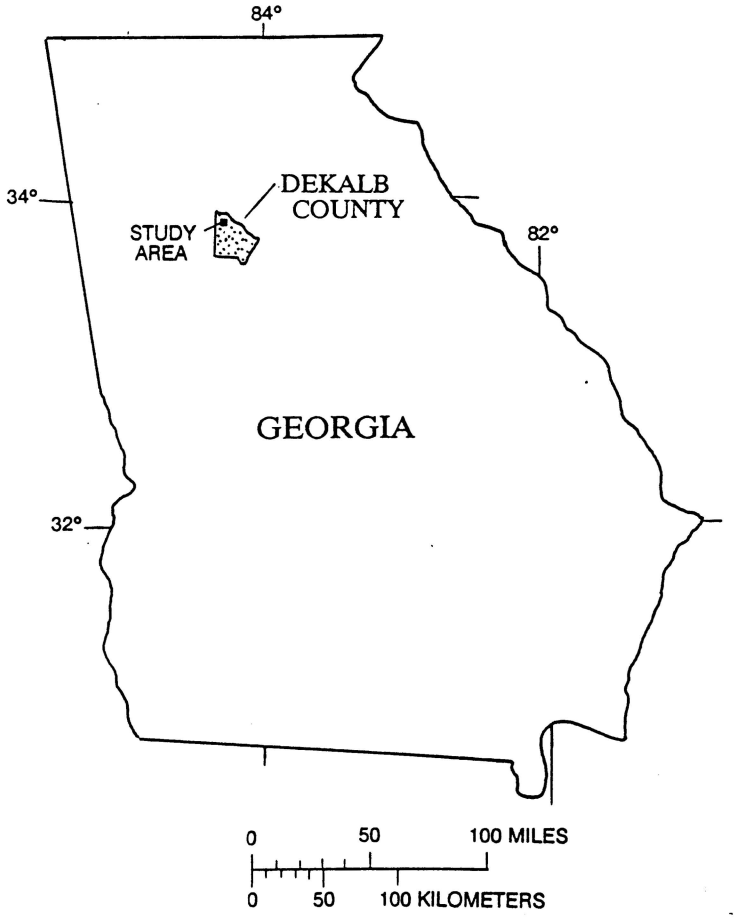

Figure 1. Location of study area in Georgia.

INVESTIGATION

Six factors have been considered to influence the hydrogeology and hence, ground-water availability in metamorphic rocks of the Piedmont province. These factors include (1) rock type(s); (2) discontinuities due to compositional differences, foliation, joints, other fractures, and faults; (3) topography; (4) spatial relation of rock type(s) and discontinuities to topography; (5) depth of weathering; and (6) recharge area. Because these factors have a high degree of spatial variability, a site-specific evaluation is needed to select drilling locations. Well drilling has shown that well yields can vary significantly over a small area.

RESULTS

An evaluation in the study area indicated that four of the six factors numbered above were present that influence ground-water availability. These factors were discontinuities (2); topographic relief (3); spatial relation of rock type and discontinuities to topography (4); and recharge area (6). However, rock type (1) and depth of weathering (5) did not indicate potential for high-yielding wells.

The dominant rock type in the study area is a fine-grained granitic gneiss comprised of chlorite, biotite, muscovite, quartz, and feldspar, interlayered with thin discontinuous layers of feldspar-hornblende gneiss. Pegmatites and vein quartz are present as small concordant lenses and pods; however, they are not abundant throughout the study area. The fine-grained texture of these rocks is the result of shearing granulation under high confining pressure. This fine grain size, combined with a uniformity of texture, results in low permeability. Weathering generally is uniform and shallow, and relatively fresh rock is exposed along most of the small creeks that divide the study area.

Differential weathering along shear foliation was observed in rocks in the central and western parts of the study area. Weathering along shear foliation has enhanced discontinuities that trend northeast, and are inclined 45 to 50 degrees to the southeast. Two sets of well-developed, nearly vertical joints are aligned N50-70E and N20-40W and their spacing ranges from less than 1 inch to approximately 30 inches.

Small valleys and topographic lows in the ridges are aligned with the shear foliation and the two joint sets.

Drilling locations were selected at four sites based on discontinuities present in the dominant rock type and their relation to topography. However, the hydrogeologic evaluation indicated it was unlikely that high-yielding wells could be developed in the study area. Although discontinuities were present in the rock, the fine-grained texture and shallow depth of weathering could reduce the probability of locating high-yielding wells.

Four wells were drilled during the fall of 1990. Wells 1, 2, and 3 were drilled in areas having favorable topographic settings at the intersection of the topographically-enhanced structural geologic features--the northeast-trending foliation and joint set (N50 - 70E) and the N20 - 40W joint set. Well 4 also was drilled at an intersection of these features, but in a less favorable topographic setting.

Well 1 was drilled at the site that had the best potential for development based on the hydrogeologic evaluation. The well was drilled to a depth of 600 feet and yielded more than 115 gallons per minute. Well 2 was drilled to a depth of 365 feet and yielded more than 400 gallons per minute. The hydrogeologic evaluation indicated that the sites for wells 3 and 4 had less potential for producinghigh-yielding wells. Well 3 was drilled to a depth of 350 feet and yielded only 1 gallon per minute. Well 4 was drilled to a depth of 465 feet and produced more than 300 gallons per minute.

DISCUSSION

Data collected during drilling and further evaluation of the sites indicate that there is a greater difference in lithology in the study area than suggested in earlier investigations. Wells 1 and 2 penetrated rocks having abundant chlorite; enough to impart a schistose texture and to enhance weathering. Rocks penetrated at well 3, like those at the surface, are very quartz-rich, less chloritic, fine-grained, and sheared; and thus, have little permeability. Well 4 penetrated feldspathic zones (more thoroughly weathered) and an abundance of vein quartz, both of which could increase permeability.

Results of this evaluation demonstrate the importance of understanding the controlling factors governing ground-water availability and yield in the metamorphic rocks of north Georgia. Because of the large number of variables that influence the yield and production of wells, each area is unique and should be evaluated on a site-specific basis.